Given that the Bois Ellen Co-operative is heavily involved in caring for its residents, the design team was encouraged to provide the owner with a building that will require only standard levels of maintenance, straightforward operations, and an improved and durable building envelope.

METHODOLOGY

The integrated design process (IDP) offers housing development teams a framework whereby an interdisciplinary team of experts establishes objectives and then engages in an iterative trade-off, feedback and optimization process to achieve as many objectives as possible within given capital and operating budget restraints.

The IDP charrette that was organized to develop a design for part "Y" of the Bois Ellen Co-operative encouraged participants to explore and consider all aspects of the project that could influence the performance criteria. Participants and stakeholders focused on the design of the building envelope, mechanical building systems, and the potential complementarity and interdependency between systems that together can further improve overall building performance and user comfort.

FINDINGS

The integrated design process

A whole building energy consumption simulation analysis was engaged from the beginning of the design process as a useful way to understand and forecast the energy performance of the proposed building, given the many design options considered. The project team sought to use "passive" means to achieve energy efficiency. Passive, low-energy design principles inspired many of the technical innovations considered for this project. Many of the building science recommendations and technical innovations emerged from the collective experience of the expert consultants, client and others involved in the IDP and were applied to the following three areas of focus:

1. *Improvements to the building envelope*—essential to the long-term energy efficiency of a building.
2. *Improvements to building systems*—including heating, ventilation and air conditioning (HVAC), plumbing and electrical systems—important to overall building performance.
3. *Implementation of effective mechanisms of coordination*—testing and performance monitoring during the construction phase and during a year-long monitoring phase necessary to provide feedback on the success of the measures included in the building.

Improvements to the building envelope

Windows and doors – strategic selection and installation

In most building envelopes, windows and doors are weak points in the overall thermal resistance of the exterior wall assembly. For the Bois Ellen Co-operative project, it was determined that, according to the simulations of the whole building analysis, an initial investment in triple-glazed windows with a good performance frame on north-facing facades could result in significant energy savings.

Insulation – placement and thickness

To meet or exceed the insulations values of the Novoclimat standards, the IDP team conceived an exterior wall assembly with 125 mm (5 in.) of semi-rigid "outsulation" (insulation situated outside of the supporting steel stud wall). This configuration has a nominal RSI of 4.4 (R-25), helps to reduce the risk of condensation and moisture damage within the wall assembly and protects the integrity of the air barrier that is placed over the exterior surface of the exterior wall sheathing. This results in a higher performing, durable building envelope system and reduces the complexity of labour and associated costs. It can also help reduce longer-term repair and maintenance costs.

The whole building energy analysis for the Bois Ellen Co-operative suggested that a 125-mm (5-in.) thickness of rigid roof insulation with a nominal RSI of 5.18 (R-29.5) would be a cost-effective strategy for reducing heat loss in the winter and heat gain in the summer.

Thermal bridging – mitigation

Mitigating thermal bridging is extremely important to ensure the overall integrity and durability of a building envelope. The overall effective insulation values of even very highly insulated wall assemblies can be significantly undermined by thermal bridges. For the Bois Ellen Co-operative, the project team focused on reducing thermal bridging in the following locations.

A. Through the exterior wall insulation: The potential thermal bridge of the sub-girts that hold the exterior insulation in place and support the exterior cladding materials could be significant, due to the ubiquity of the girts on all exteriors walls, making mitigation an important goal for the project team. The team considered multiple affordable ways of minimizing this common thermal bridge, such as using non-conductive sub-girts or by using thermally broken sub-girts.

B. At the structural lintels supporting the masonry cladding: Given the heavier loads carried by the structural lintels that support masonry cladding, this thermal bridge can be more difficult and costly to mitigate. The project team considered ways in which the masonry lintels could be designed so that their installation was thermally broken. For example, the team considered reducing thermal bridging by using intermittent (rather than continuous) anchoring of the structural lintels back to the building structure. As well, the team considered ways to thermally break the intermittent structural supports with gaskets and the use of other non-conductive materials while still retaining the required structural strength necessary to support the masonry cladding.

C. At balconies and loggias: Fully cantilevered balconies represent major thermal bridges that often result in cold floors and ceilings where they join the floor slabs. The project team elected to use non-conductive reinforcement bars and rigid insulation at the structural joints between the concrete floor slabs and the exterior balcony and loggia slabs to reduce heat loss.

Passive solar shading – brise-soleil

The design team proposed solar and heat gain control devices (brise-soleil) be installed on the southwest-facing building facade to permit solar heat gains in the winter, but to mitigate solar heat gains (by about 80 per cent) in the summer (figure 2). A combination of insulated glazing units (IGUs) that permit high solar gain and fixed brise-soleil assemblies attached at the exterior of the building envelope can selectively reduce solar heat gain to help reduce air conditioning loads for the greatest benefit of the building's residents. Although the fixed shading devices devised by the project team are not expected to fully eliminate summertime heat gain, their simplicity and minimal maintenance was a critical component of the decision-making process that led to their inclusion in the project design.

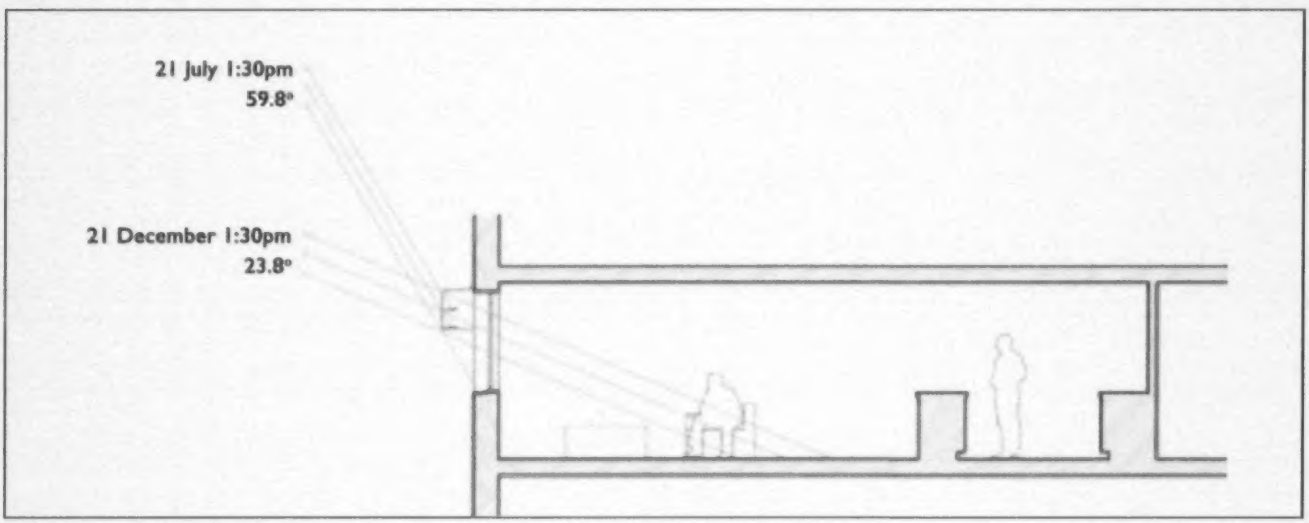

Figure 2 Solar penetration on July 21 and December 21 on the southwest facade

Section view of the southwest facade of the six-storey building at proposed fixed brise-soleil showing solar penetration at 1:30 p.m. in summer and winter. (Source: L'OEUF)

Consideration of budget constraints versus the benefits of the installation of brise-soleil on other building facades suggested that brise-soleil on all building facades were not to be implemented at initial construction. In order to add adaptability and future-proof the building, thermally broken structural anchoring plates to support future brise-soleil were proposed.

Vegetated roof

The roof assembly of the six-storey building will be constructed to be ready to receive a future vegetated roof. Though vegetated roofs are proposed for the initial construction of other roofs on site, a vegetated roof could not be accommodated within the project budget for the six-storey building. A light-coloured roof membrane and root barriers for a future vegetated roof will be installed.

Improvements to building systems

Ventilation strategy

A strategically balanced mechanical ventilation strategy was proposed for the project. This allows for partial individual control through the installation of heat recovery ventilator units (HRVs) in each unit combined with the overall benefits that can be gained from the efficiencies of centralized preconditioning of makeup fresh air (including preheating in the winter and dehumidification in the summer). Figure 3 shows how the placement of a centralized air intake at the roof of the building can benefit the quality of indoor air. On sunny days in the winter and shoulder seasons, this hybrid ventilation system is supplemented by centralized solar preheating.

Plumbing strategy for water efficiency

The proposed plumbing fixtures in this project were water-efficient, reduced-flow models. Additionally, heat is to be recuperated and reintegrated into the domestic hot water system from some shower wastewater. The plumbing system was also designed to allow for future conversion of hot water heating from electric to solar.

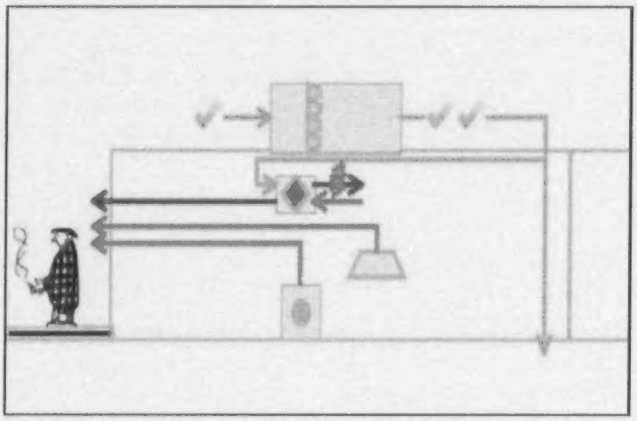

Figure 3 The proposed ventilation concept for Bois Ellen: the outside air intake is located at the roof, away from common smoking areas. Air is preconditioned by a large commercial system before being supplied to the individual unit HRVs. The roof-mounted system boasts high-efficiency filtration that improves outside air quality by removing fine particulates. (Clipart smoker: free.clipartof.com. Image concept: Frédéric Genest, Pageau Morel)

Resident engagement and responsibility

Once the project is occupied, systems monitoring and resident engagement can make the building operations as efficient as possible. Additionally, as the systems are in part controlled by the residents and metered individually, there can be additional incentives for residents to form energy-efficient habits.

Selection of low pollutant emitting materials

To improve indoor air quality (IAQ), many of the affordable building materials (especially interior finishes, although not including built-in furnishings) contain low or no volatile organic compounds (VOCs).

Implementation of effective measures for coordination, commissioning and performance monitoring

Coordination / commissioning agent

The tendering documents required that the general contractor hire a "commissioning agent" to ensure a coordinated and successful installation of all building systems, including the administration of warranties and maintenance programs.

Durability, maintenance and varied life cycles

Given the differences between mechanical systems (with moving parts) and fixed assemblies (such as most parts of a building envelope), there will invariably be variations in the durability and maintenance requirements of different building systems and elements. Such differences were taken into account in the analysis of the building's life cycle and the planning of its operation and maintenance programs.

Testing for airtightness

The Bois Ellen Co-operative project is targeting to achieve 0.9 air changes per hour (at 50 pascals of air pressure); a significant improvement over the Novoclimat standard for airtightness of 1.5 air changes per hour (at 50 pascals). The integrity of the exterior envelope, the airtightness between adjacent units, and between units and corridors will be tested at two times:

1. after envelope construction but before building services and interior gypsum board installation; and
2. after building services installation but before substantial completion.

Monitoring the operation of windows and doors and mechanical ventilation systems

The operation of doors and windows can greatly affect the heating, cooling, ventilation and air quality of a building. There is, therefore, a need to better understand occupant behaviour. Monitoring and post-occupancy evaluations of window and door operation is planned at initial occupancy, at three months, six months and one year.

CONCLUSIONS

The baseline case scenario analyzed for Bois Ellen projected a total energy demand of about 240 kWh/m^2/year (22.30 kWh/ft^2/year) with a heating demand of about 144 kWh/m^2/year (13.38 kWh/ft^2/year). The combined effects of implementing the energy conservation measures (ECMs) developed during the IDP for Bois Ellen resulted in a projected reduced total energy demand of about 135 kWh/m^2/year (12.54 kWh/ft^2/year), including a heating demand of about 43 kWh/m^2/year (3.99 kWh/ft^2/year). This results in a projected approximate 42 per cent reduction in overall energy use, and an approximate 70 per cent reduction in heating energy use.

In this study, an integrated design process (IDP) and a whole building analysis have been valuable design tools that have facilitated the integration of environmental and sustainable measures for low- to mid-rise MURBs at the early design stage. The targeted goal of seeing if the building's final design could achieve an overall energy performance reduction of about 40 per cent over average residential energy use in Quebec was achieved. Because of the likely composition of future residents of the Bois Ellen Co-operative, a mix of seniors and young families, durable, easy-to-use and low-maintenance building systems will be included in this project. The engagement and education of the residents in the operation and maintenance of their building may also play a key role in determining the future overall energy use and energy savings. Other important goals, such as improved thermal comfort, high indoor air quality and long-term envelope durability have all been integrated into the final design, while respecting the constraints of affordability.

IMPLICATIONS FOR THE HOUSING INDUSTRY

Design and analysis methods, including an integrated design process (IDP) and a whole building analysis, can be useful tools used in complex building projects, such as multi-unit residential buildings (MURBs). These tools and processes can be more broadly adopted and implemented to facilitate energy-efficient and robust building designs, and this project demonstrated how energy efficiency and sustainability can affordably be incorporated into the design of low-energy MURBs without adding to future operational maintenance and building complexity.

Principal contributors: Daniel Pearl and Cecilia Chen, L'OEUF s.e.n.c.
Frédéric Genest, Pageau Morel and Associates Inc.
Curt Hepting, EnerSys Analytics Inc.

CMHC Project Manager: Woytek Kujawski

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700 Montreal Road
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K1A 0P7

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